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Chicot County, Arkansas

National Eutrophication Survey, Las Vegas, Nev

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

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Report
on
Chicot Lake
Chicot County
Arkansas
EPA Region VI
Working Paper No. 404

With the cooperation of the
Arkansas Department of Pollution
Control and Ecology
and the
Arkansas National Guard
January, 1977

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1

Report on Chicot Lake, Chicot County, Arkansas

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Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

KEY WORDS AND DOCUMENT ANALYSIS

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REPORT ON CHICOT LAKE

CHICOT COUNTY, ARKANSAS

EPA REGION VI

by

National Eutrophication Survey

Water and Land Monitoring Branch
Monitoring Applications Laboratory
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Eutrophication Survey Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 484

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

January 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Arkansas Department of Pollution Control and Ecology for professional involvement, to the Arkansas National Guard for conducting the tributary sampling phase of the Survey, and to those Arkansas wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Water Division of the Arkansas Department of Pollution Control and Ecology provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

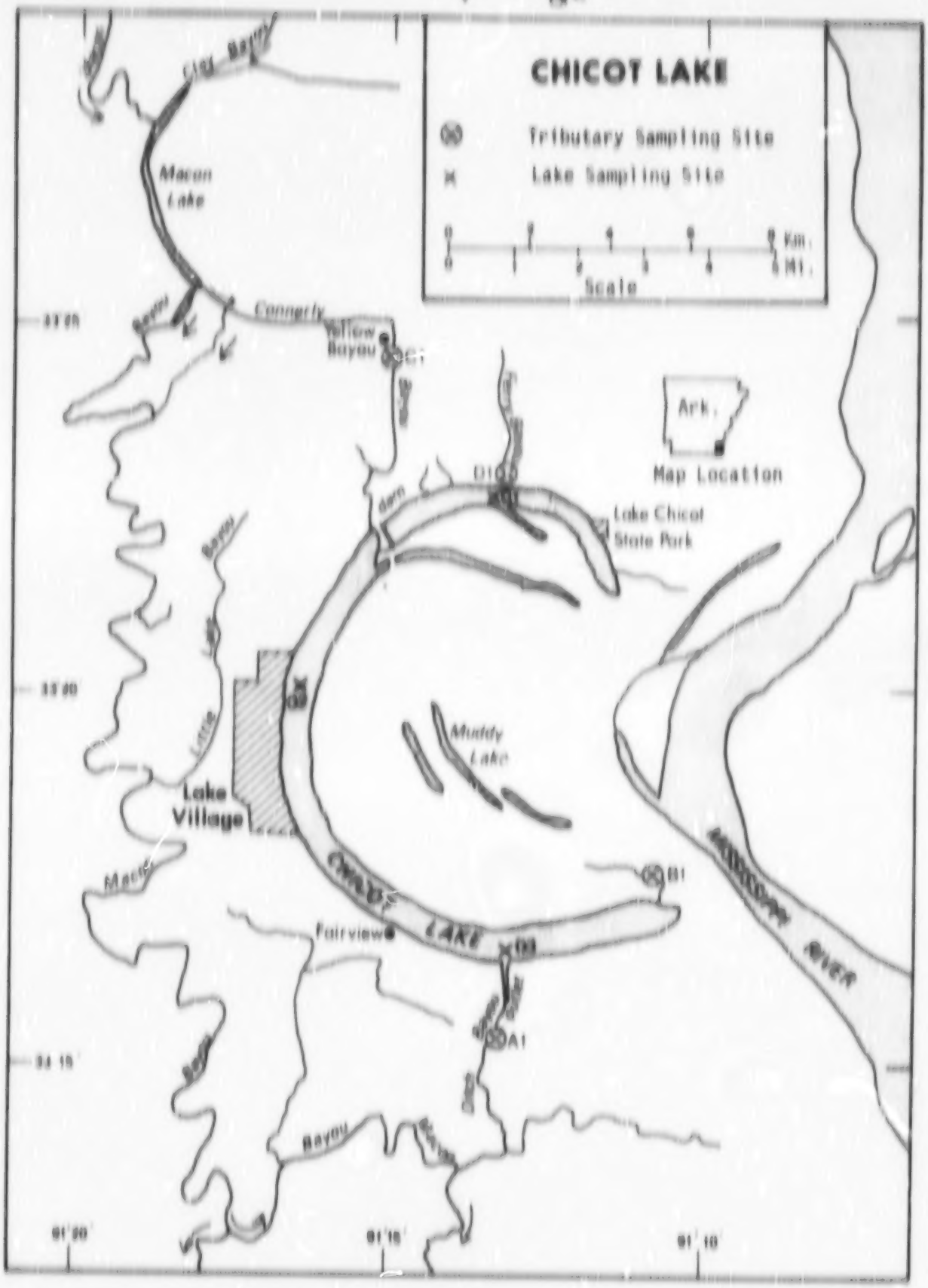
Major General Thomas C. Armstrong, the Adjutant General of Arkansas, and Project Officer Colonel Lavaun M. James, who directed the volunteer efforts of the Arkansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ARKANSAS

LAKE NAME	COUNTY
Beaver	Benton, Carroll, Washington
Blackfish	Crittenden, St. Francis
Blue Mountain	Logan, Yell
Bull Shoals	Baxter, Boone, Marion (Taney, Ozark in MO)
Catherine	Garland, Hot Spring
Chicot	Chicot
DeGray	Clark, Hot Spring
Erling	Lafayette
Grand	Chicot
Greer's Ferry	Van Buren, Cleburne
Hamilton	Garland
Millwood	Hempstead, Howard, Little River, Sevier
Nimrod	Perry, Yell
Norfork	Baxter, Fulton (Ozark in MO)
Ouachita	Garland, Montgomery
Table Rock	Boone, Carroll (Barry, Taney in MO)


CHICOT LAKE
Tributary Sampling Site
Lake Sampling Site
Km.
Mi.
Scale
Ark.
Map Location
Lake Chicot State Park
Macon Lake
Connerly
Yellow Bayou
Dam
Muddy Lake
Lake Village
Fairview
LAKE
MISSISSIPPI RIVER
Bayou
91°20'
91°15'
91°10'

REPORT ON LAKE CHICOT, ARKANSAS
STORET NO. 0506

I. CONCLUSIONS

A. Trophic Condition:*

Based upon field observations and Survey data, Lake Chicot is considered eutrophic, i.e., nutrient rich and highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake.

Chlorophyll a values ranged from a low of 1.1 µg/l in the summer to a high of 30.5 µg/l in the spring with a mean of 13.7 µg/l. The mean Secchi disc transparency was 66 cm (26 inches) at Station 01, and 20 cm (8 inches) at the less productive but more highly enriched lake Stations 02 and 03, suggesting light is the growth limiting factor in parts of Lake Chicot rather than nutrient availability. Of the 16 Arkansas lakes sampled in 1974, only 1 had greater median total phosphorus, dissolved orthophosphorus, and inorganic nitrogen levels than Lake Chicot.

Survey limnologists observed an algal bloom during the October sampling period and floating aquatics in the

*See Appendix E

vicinity of sampling Station 01. In 1971, Kotelle and Uttormark reported siltation and insecticides contributed from agricultural runoff to be major lake problems.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Lake Chicot was limited by available nitrogen during the spring and fall sampling seasons. Spikes with nitrogen or phosphorus and nitrogen simultaneously resulted in increased assay yields. The addition of phosphorus alone did not produce a growth response. The lake ratios of available inorganic nitrogen to orthophosphorus (N/P) also indicate primary limitation by nitrogen during spring and fall, but phsophorus limitation during the summer.

C. Nutrient Controllability:

1. Point sources -

There are no known point sources contributing to Lake Chicot. The present loading of 6.64 $g/m^2/yr$ is nearly eight times that proposed by Vollenweider (1975) as eutrophic for a lake of such volume and retention time. However, Vollenweider's model may not apply to highly turbid lakes, like Lake Chicot, where light penetration in the surface waters is severely restricted by the high concentrations of suspended solids.

Although there are no known point sources impacting Lake Chicot, nutrient levels and background nutrient loadings for

the tributaries flowing into the lake are unusually high (see Section IV-D). Determination of the extent of agricultural runoff and of unknown sources contributing to the lake is needed to determine the cause of such high nutrient inputs to the lake.

2. Nonpoint sources -

Nonpoint sources contributed all of the nutrient loads reaching Lake Chicot. Connerly Bayou contributed 90.7% of the total phosphorus load and minor tributaries were estimated to have contributed 9.0% of the total.

In general, few lakes are nitrogen limited as a result of low nitrogen. Rather, excessive phosphorus levels shift limitations to nitrogen or other factors. Regardless of the primary nutrient limitation suggested by either algal assay or nutrient ratios, the most feasible approach to nutrient control, if desirable, is through available phosphorus control technology and subsequent establishment of phosphorus limitation within the water body.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry was provided by the Arkansas Department of Pollution Control and Ecology. Tributary flow data were provided by the Arkansas District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by the mean flow of the outlet. Precipitation values are estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 21.45 km^2.
2. Mean depth: 2.7 meters.
3. Maximum depth: 7.6 meters.
4. Volume: 58,837 x 10^6 m^3.
5. Mean hydraulic retention time: 49 days.

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries -

Name	Drainage area(km^2)	Mean flow (m^3/sec)
C-1 Connerly Bayou	932.4	12.21
Minor tributaries and immediate drainage -	92.6	1.41
Totals	1,025.0	13.62
2. Outlet - A-1 Ditch Bayou	1,046.4	13.82

C. Precipitation:

1. Year of sampling: 161.3 cm.
2. Mean annual: 160.3 cm.

III. LAKE WATER QUALITY SUMMARY

Lake Chicot was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from three stations on the lake and from a number of depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composed for algal assays. Maximum depths sampled were 4.6 meters at Station 01, 7.0 meters at Station 02, and 8.8 meters at Station 03. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/26/74	1. Stephanodiscus	1,904
	2. Melosira	360
	3. Cryptomonas	260
	4. Actinastrum	154
	5. Dactylococcopsis	92
	Other genera	92
	total	2,856
06/05/74	1. Merismopedia	566
	2. Melosira	536
	3. Cryptomonas	447
	4. Oscillatoria	209
	5. Cyclotella	179
	Other genera	1,072
	total	3,009
10/16/74	1. Cyanophytan Filament	2,201
	2. Melosira	1,313
	3. Flagellates	726
	4. Stephanodiscus	726
	5. Synedra	311
	Other genera	1,303
	total	6,740

f. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/26/74	01	30.5
	02	3.0
	03	1.6
06/05/74	01	30.5
	02	4.0
	03	1.1
10/16/74	01	29.2
	02	16.4
	03	7.2

g. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 03/26/74

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.095	0.440	13.0
0.05 P	0.145	0.440	13.5
0.05 P + 1.00 N	0.145	1.440	39.6
1.00 N	0.095	1.440	37.6

b. 10/16/74

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.065	0.114	8.5
0.05 P	0.115	0.114	8.5
0.05 P + 1.00 N	0.115	1.114	22.6
1.00 N	0.065	1.114	16.2

F. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that Lake Chicot had extremely high potential for primary productivity during the spring and fall sampling periods. The lake was nitrogen limited at those times as indicated by the increased yields of the test alga in response to the addition of inorganic nitrogen. Spikes with phosphorus and nitrogen simultaneously resulted in a maximum yield. Spikes with phosphorus alone did not produce a response beyond the control yield.

The mean N/P ratios in the lake data were 6/1 and 4/1 in the spring and fall, respectively, indicating primary limitation by nitrogen. The lake N/P ratio during summer sampling was 17/1, suggesting phosphorus limitation at that time (a mean N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Arkansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of January, March, and April when two samples were collected. Sampling was begun in June 1974, and was completed in June 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Arkansas District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in $kg/km^2/yr$, in Connerly Creek at Station C-1, and multiplying the means by the ZZ area in km^2.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
C-1 Connerly Bayou	129,285	90.7
b. Minor tributaries and immediate drainage (nonpoint load) -	12,870	9.0
c. Known municipal STP's - None		
d. Septic tanks* -	5	<0.1
e. Known industrial - None		
f. Direct precipitation** -	375	0.3
Totals	142,535	100.0

2. Output - A-1 Ditch Bayou 115,735

3. Net annual P accumulation - 26,800

*Estimate based on 20 lakeside residences and 1 state park.
**Estimated (see NES Working Paper No. 175).

C. Annual total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
C-1 Connerly Bayou	773,015	88.5
b. Minor tributaries and immediate drainage (nonpoint load) -	76,765	8.8
c. Known municipal STP's - None		
d. Septic tanks* -	250	<0.1
e. Known industrial - None		
f. Direct precipitation** -	23,155	2.7
Totals	873,185	100.0
2. Output - A-1 Ditch Bayou	700,900	
3. Net annual N accumulation -	172,285	

*Estimate based on 20 lakeside residences and 1 state park.
**Estimated (see NES Working Paper No. 176).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Connerly Bayou	139	829

E. Mean Nutrient Concentration in Ungaged Streams:

Tributary	Mean Total P (mg/l)	Mean Total N (mg/l)
B-1 Unnamed Creek	0.513	2.036
D-1 Ferry Bayou	0.408	1.768

Nutrient concentrations for the above two tributaries are in line with those found in the gaged tributary (C-1 Connerly Bayou) flowing into Lake Chicot.

F. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his eutrophic loading is that at which the receiving waters would become eutrophic or remain eutrophic; his oligotrophic loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between eutrophic and oligotrophic.

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading ($g/m^2/yr$)
Estimated loading for Lake Chicot	6.64
Vollenweider's eutrophic loading	0.88
Vollenweider's oligotrophic loading	0.44

V. LITERATURE REVIEWED

Ketelle, Martha J. and Paul O. Uttormark, 1971. Problem Lakes in the United States. U.S. Environmental Protection Agency Project #1010 EHR. University of Wisconsin, Madison, Wisc.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A. 1975. Input-Output Models With Special Reference to the Phosphorus Loading Concept in Limnology. Schweiz. Z. Hydrol. 37:53-84.

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VI. APPENDICES

APPENDIX A
CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B
TRIBUTARY FLOW DATA

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APPENDIX C
PHYSICAL AND CHEMICAL DATA

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APPENDIX D

TRIBUTARY DATA

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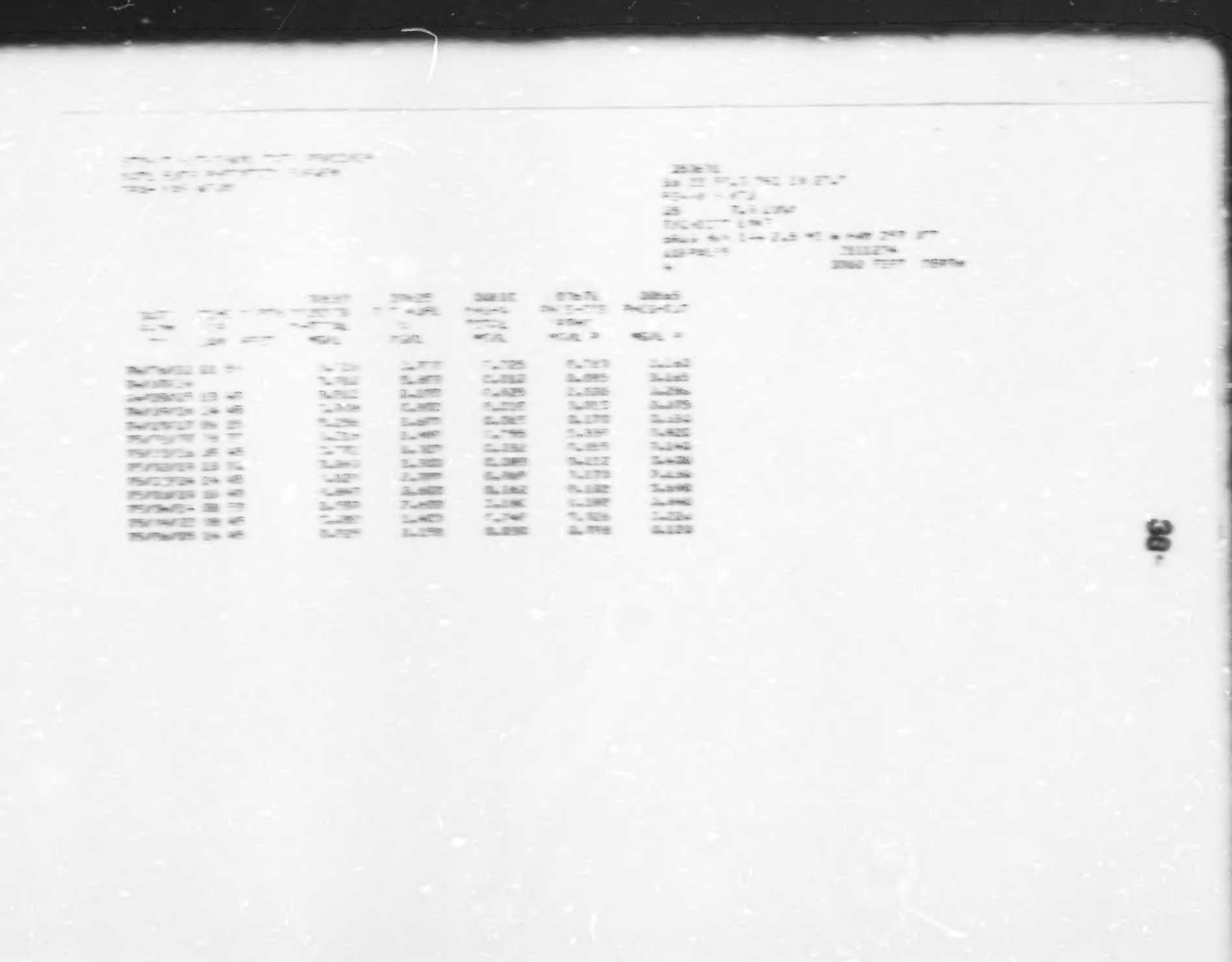
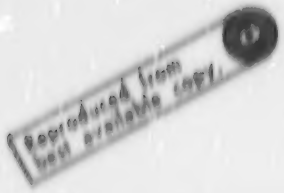


APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF ARKANSAS



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